Chapter 2

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2. Affected Environment

Introduction

The Great Dismal Swamp National Wildlife Refuge (NWR) is the largest intact remnant of a vast ecosystem that once covered more than one million acres of southeastern Virginia and northeastern North Carolina.

Formal protection of this resource began in 1973, when Union Camp Corporation (a local forest products company) donated 49,097 acres to The Nature Conservancy. The Nature Conservancy conveyed the donated land to the federal government, which, combined with additional purchased land, was used to establish the Great Dismal Swamp NWR in 1974.

Great Dismal Swamp Watershed. *The Great Dismal Swamp National Wildlife Refuge (NWR) is the largest intact remnant of a vast ecosystem that once covered more than one million acres of southeastern Virginia and northeastern North Carolina. Satalite image. USFWS.*

The Dismal Swamp Act of 1974 directs the U.S. Fish and Wildlife Service to:

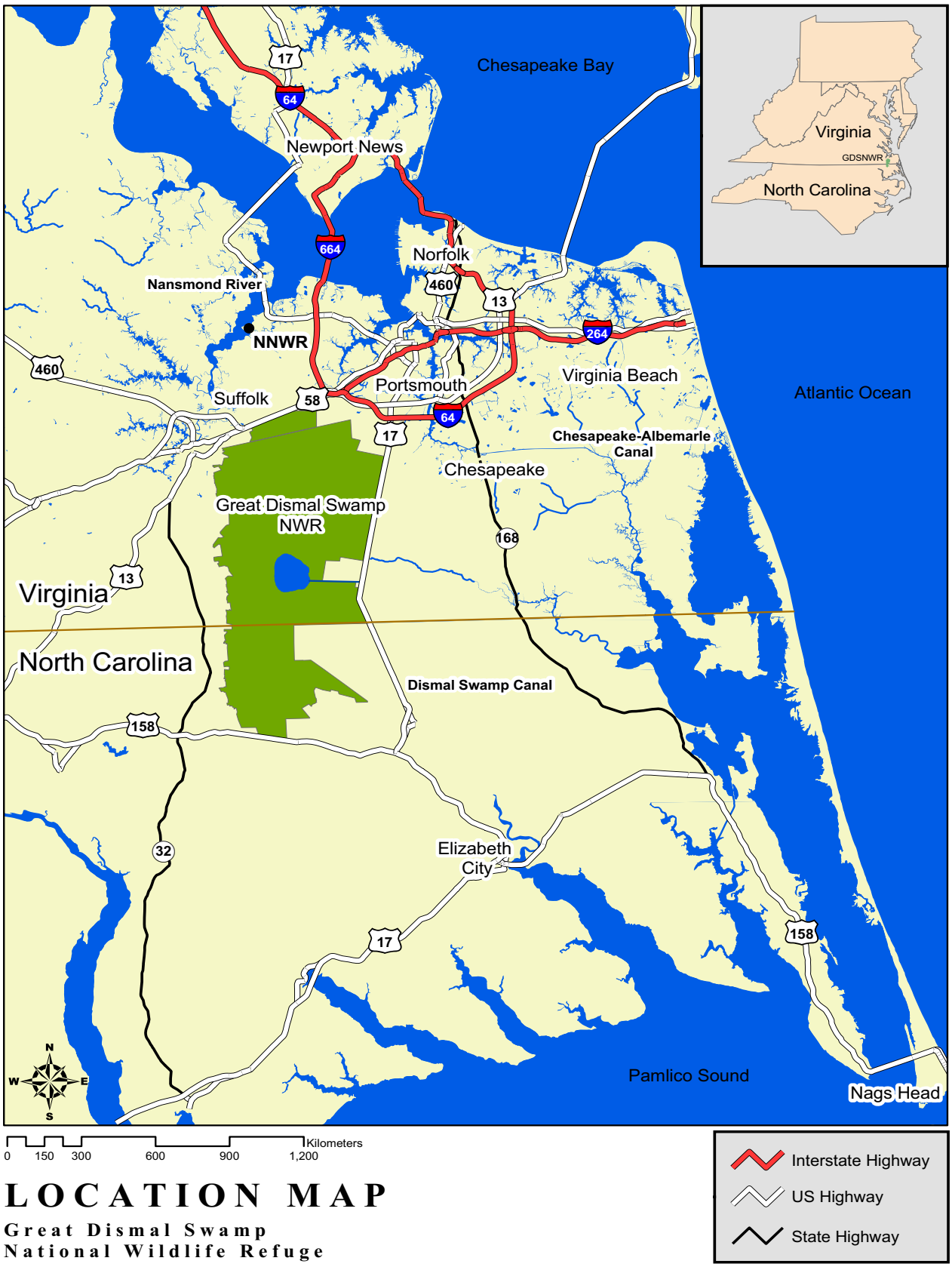
"Manage the area for the primary purpose of protecting and preserving a unique and outstanding ecosystem, as well as protecting and perpetuating the diversity of animal and plant life therein. Management of the refuge will be directed to stabilize conditions in as wild a character as possible, consistent with achieving the refuge's stated objectives."

With a secondary purpose to:

"Promote a public use program when not in conflict with the primary objectives of the refuge."

This document also addresses management of the Nansemond NWR, a 423-acre parcel located on the southeastern side of the Nansemond River approximately 5 miles north of the Great Dismal Swamp NWR. The Nansemond NWR was created in 1973 when 207 acres were transferred from the U.S. Navy to the U.S. Fish and Wildlife Service, pursuant to the Federal Property and Administrative Services Act of 1949, as amended, 63 Stat. 377 (40 U.S.C. 471). In 1999, an additional 216 acre parcel of upland grassland and forested stream corridor was added as a result of the Base Realignment and Closure (BRAC)

Figure 2-1



LOCATION MAP

Great Dismal Swamp National Wildlife Refuge

process. The Nansemond NWR is an unstaffed, satellite refuge administered through the Great Dismal Swamp NWR. It is not open to the public.

Physical Environment

Location and Size

The name "Dismal Swamp" originated in colonial days, referring to the poorly drained area that lies between the James River in southeastern Virginia and the Albemarle Sound in North Carolina (Oaks and Whitehead, 1979). The Great Dismal Swamp originally extended over more than one million acres in southeastern Virginia and northeastern North Carolina (USDOI, 1974). Clearing and draining for agricultural uses and residential development have greatly reduced the size of the original ecosystem and significantly altered the water cycle and fire regime of the remaining area.

The Great Dismal Swamp NWR is but one component of an extensive conservation network providing protection to the remaining resources. Within the GDS watershed other lands are protected by the City of Chesapeake, Virginia Department of Game and Inland Fisheries (VDGIF), Virginia Department of Conservation and Recreation (VDCR), North Carolina State Parks, North Carolina Wildlife Resources Commission, The Nature Conservancy, the U.S. Navy, the U.S. Army Corps of Engineers, and conservation easements on private lands. The total area protected by this network of organizations is approximately 185,000 acres (The Nature Conservancy, 2001).

The Great Dismal Swamp NWR currently occupies 111,200 acres. Additional planned acquisitions are anticipated to increase the refuge size to approximately 115,000 acres. The refuge is located approximately 30 miles from the Atlantic Ocean. It is delineated on the north by U.S. Highway 58, on the east by the Dismal Swamp Canal, on the south by U.S. Highway 158, and on the west by the Suffolk Scarp (Figure 2-1). The Refuge occupies portions of two cities in Virginia, Suffolk and Chesapeake, and three counties in North Carolina, Gates, Camden, and Pasquotank.

The Great Dismal Swamp NWR is one of seventy wildlife refuges in the northeastern administrative region of the U.S. Fish and Wildlife Service. The refuge is the largest in Region 5, representing nearly 25 percent of all service owned land found in the northeast region. The refuge straddles the region's southern boundary with approximately 33 percent of the refuge overlapping into the Service's southeastern region, Region 4.

Physiography and Topography

Great Dismal Swamp NWR lies in the Embayed Section of the Atlantic Coastal Plain, which consists of three wide, gently sloping terraces separated by longitudinal, eastward-facing escarpments. The middle terrace, known as Dismal Swamp Terrace, is bisected by the Deep Creek swale, also running north-south. The refuge is located on the western portion of this terrace, between the Suffolk Escarpment (Scarp) and the Deep Creek Swale. Churchland Flat bounds the refuge on the north.

The refuge can be divided into three physiographic zones: Lake Drummond, the forested wetland, and a transition zone. Lake Drummond, a 3,108 acre shallow lake, is located near the center of the refuge. The forested wetland portion, the predominant feature of the refuge, is sharply disrupted on three sides by the Dismal Swamp Canal and U.S. Highways 58 and 158. Along its western edge, the transition zone from swamp to uplands is more gradual, creating an area of mixed characteristics.

Along the Suffolk Scarp, on the western side of the Great Dismal Swamp NWR, elevations rise and relief is variable. Traveling eastward across the refuge from the Suffolk Scarp, elevation drops at a rate of one foot per mile to the Deep Creek Swale (east of the Dismal Swamp Canal). In the Virginia portion of the refuge, elevations range from 15 to 25 feet; in Pasquotank County, North Carolina, elevations range from 10 to 20 feet; Camden County varies from 21 feet or lower. The topography exhibits a gentle west to east slope imposed on an even gentler north to south slope. The normal surface elevation of Lake Drummond is 18.65 feet.

Nansemond NWR also lies within the outer part of the Atlantic Coastal Plain physiographic province. The generalized physiography of the area is known for a "stair-step" appearance, consisting of wide, gently eastward sloping planes separated by linear, steeper, eastward-facing scarps. The planes slope eastward at less than two feet per mile, whereas the scarps have slopes of as much as 50-450 feet per mile through short distances.

The Nansemond NWR is situated on the east bank of the Nansemond River, east of the Suffolk Scarp. Elevation varies from sea level to 21 feet above sea level. Much of the Nansemond NWR is a well-drained knoll, with drainages emptying into the river and marshes.

Geology

Great Dismal Swamp NWR and Nansemond NWR are underlain by several geologic formations: the four most significant are the Yorktown, the Norfolk, the London Bridge, and the Sandbridge formations (USDOI, 1979).

The Yorktown Formation is the oldest and deepest unit of the four, consisting chiefly of impermeable clay. The top of the Yorktown Formation is within 15 feet of the surface throughout much of the western part of the refuge and within 25 feet of the surface in the eastern part.

The Norfolk Formation overlays the Yorktown Formation beneath most of the refuge and is closely associated with the Great Dismal Swamp NWR's water budget. The Norfolk Formation is composed of two layers. Its lower level consists primarily of coarse sand and is very permeable. The upper layer consists of eight strata, three of which play an important role in the hydrology of the refuge. The coarse-sand stratum under the Suffolk Scarp and the extreme western part of refuge serves as a shallow aquifer. The Norfolk Formation is exposed at elevations between 25 to 70 feet in a belt less than a mile wide that runs north-south along the Suffolk Scarp. This is the groundwater recharge area for the aquifer. The formation then grades eastward under the refuge into the medium-sand stratum. This stratum underlies most of the Great Dismal Swamp NWR and in turn grades into fine sand beneath the area east of refuge. Groundwater input from the Norfolk Formation accounts for the majority of water that upwells in the swamp.

The London Bridge Formation, clay silt that overlays the Norfolk Formation, occurs throughout the eastern and most of the western portions of the refuge. The Sandbridge Formation generally overlies the London Bridge Formation, where the London Bridge is present, or directly overlies the Norfolk Formation. It is composed of two sheet-like deposits: a lower layer of sand and an upper layer of silty clay. The London Bridge and Sandbridge Formations confine the Norfolk aquifer. More recent deposits over these formations consist of a layer of inorganic soils and an overlying organic layer of peat.

Soils

Organic Soils

The soils of Great Dismal Swamp NWR play a critical role in supporting its wetland communities. Organic soils predominate, with mineral soils confined to the toe of the Suffolk Scarp and to historic outflows of tributaries to the Elizabeth, Northwest, and Pasquotank Rivers. The organic soils are divided into two taxonomic classes: Typic Medisaprists and Terric Medisaprists. The mineral soils are divided into several classes with widely varying characteristics.

Typic Medisaprists are organic soils more than 51 inches thick, underlain by mineral subsoil. There are two types of Typic Medisaprists within the Great Dismal Swamp NWR: those composed of finely divided and those composed of coarsely divided soil material. Terric Medisaprists are organic soils more than 16 inches and less than 51 inches thick, underlain by loamy or sandy mineral subsoil.

In general, the organic soils of the refuge are black, fine-grained, highly decomposed mucky peat. Partially decomposed logs and stumps are buried in the decomposed organic material at depths ranging from a few inches to five feet. These soils are characterized by poor or very poor drainage, high acidity, and mean annual soil temperatures between 59° and 72° Fahrenheit. Permeability varies with the composition of the subsoil.

During much of this century, the suitability of the swamp's organic soils for cultivation resulted in conversion of extensive tracts of swamp woodlands to agricultural lands. Although the organic soils are often saturated and extremely acid, they are quite fertile, and high yields of corn, soybeans, and grain are reported from drained organic soils on the periphery of the refuge. However, remaining areas of organic soils within the refuge have low potential for agriculture due to their thickness, buried debris, and inaccessibility.

Remaining organic soils on the refuge are subject to a number of other forces. The organic soils are highly susceptible to fire. When burned, the average combustible component of the soil is 93%, leaving a 7% ash content (Otte, 1985). Historically, uncontrolled fires directly removed organic soils from the swamp. In more recent times fire suppression has countered this trend, allowing organic soils to accumulate.

Uncontrolled drainage has also contributed to organic soil loss on the ditch side of the road-ditch corridors within the refuge. In their

natural saturated state, the swamp's organic soils are 85- 95% water. In areas that have undergone excessive drying due to drainage, these soils aggregate into a granular form that will not re-wet even under inundated conditions. The dehydrated soils oxidize at a rapid rate and their granular nature reduces saturation in the vegetation root zone, possibly facilitating the intrusion of vegetation typical of drier sites.

Where water is impounded in the refuge by elevated roads and functioning water control structures, saturated organic soils accumulate. The interplay between organic soil loss and accumulation caused by the opposing forces of burning, fire suppression, drainage, and impounding, as well as inherent soil instability, have resulted in very complex soil dynamics in the swamp. As peat accumulates, the distance between surface soils and the water table increases, renewing the oxidation/ subsidence process in the unsaturated layer with subsequent soil loss, until the cycle begins again. The key to maintaining saturated soils for wetland vegetation is, therefore, to keep the optimum distance between surface elevations and the water table.

In any case, due to their saturation and high organic matter content the organic soils are generally unsuitable for sanitary facilities, building site development, recreational development, and trails. They are highly corrosive to both steel and concrete construction.

Mineral Soils

Mineral soils are defined as those having an organic layer of less than 16 inches. Those present within the refuge include several taxonomic classes: Histic Humaquepts, Typic Ochraquults, Typic Hydroquents, Typic Umbraquults, and Typic Humaquepts.

Histic Humaquepts are soils with organic layers 8 to 16 inches thick over mineral subsoil of varying composition (sand, loam, and clay). Permeability depends upon the texture of the subsoil. They are usually poorly drained and moderately subject to fire and compaction.

Typic Ochraquults include loam and fine sandy loam soils and are mildly to strongly acidic. Drainage and permeability vary with the texture of the subsoils. Seasonal ponds form in some areas.

The Typic Hydroquent class is heavy gray clay that occurs frequently. It is a deep, very poorly drained soil. Ponds commonly form during wet seasons.

Other mineral soils occur to a limited extent along the Suffolk Scarp.

They are generally better drained and less subject to flooding than the soils described above. Although some mineral soils have high water tables and are subject to brief flooding, they are more suited for sanitary facilities, construction, and recreational development than the organic soils because their load-bearing strength is generally much higher.

Nansemond NWR Soils

Several soil series exist on the Nansemond NWR, including the Nansemond, Kenansville, and Bohicket series. The Nansemond series consists of a loamy fine sand surface layer with a sandy loam or sandy clay loam subsoil about 47 inches thick (USDA, SCS, 1984). The permeability of the Nansemond series is moderately rapid, and the soil has a seasonally high water table at depths of 2 to 3 feet.

The Kenansville series has a dark, grayish-brown loamy sand surface layer about three inches thick. The subsurface layer is an olive-yellow loamy sand about 20 inches thick. The subsoil is usually 20 inches deep and composed of brown fine sandy clay loam. The permeability of the Kenansville series is moderately rapid and it has a seasonally high water table of 4 to 6 feet.

The Bohicket series is a dark, grayish brown, silty clay loam, typically 13 inches thick. It is underlain by approximately 60 inches of clay. The permeability of the Bokicket series is very low. This series is typical of salt water marshes.

Climate

The Great Dismal Swamp NWR and Nansemond NWR are located in the humid-subtropical zone, characterized by long, humid summers and mild winters. The climate is moderated by the proximity of water bodies, including the Atlantic Ocean, Albemarle Sound, and Chesapeake Bay. The average annual temperature is approximately 60° F (15.6°C), ranging from monthly averages of 45°F(7.2 °C) in January to 79°F(26.1°C) in July. Extremes have been recorded as high as 105°F (40.6°C) and as low as 2°F (-16.7°C).

Rainfall is well distributed throughout the year and long periods of drought seldom occur. Average annual precipitation at Norfolk, Virginia, is 45.74 inches (116.2 cm), with the normal annual snowfall at 8.8 inches (22.4cm) (National Weather Service, Wakefield, Virginia). The annual potential evapotranspiration is 32 inches (81.3 cm).

Southwesterly winds dominate during the warmer months, while northwesterly winds dominate the cooler months. Northeast winds are less common and are usually associated with storm events and the passage of cold fronts. The mean wind speed is 10.5 miles per hour.

Water Resources

The Great Dismal Swamp is less than 9,000 years old; it was formed on a hillside instead of a basin and without the benefit of rivers flowing into or beside it. These facts set it apart from all other southern swamps. Regionally unique geologic formations and the presence of a shallow artesian aquifer changed the prehistoric, climax oak hickory forest into the cypress gum wetland complex of recent history. It is these same hydrologic factors that are maintaining the swamp today.

Hydrology

Many people perceive swamps as having standing water year round. This is not the case in the Great Dismal Swamp; in fact, most of the swamp's vegetation could not survive permanent inundation. The Great Dismal Swamp has an annual hydrologic cycle that results in changing water levels throughout the year. Historically, the swamp's natural hydrologic cycle has followed the seasons. Otte (1985) provides a description of this cycle:

> "In autumn the swamp was at its driest, with little or no standing water (except for Lake Drummond and some of the larger channels) and a low water table. There was little downstream movement of water; most water moved upward and out of the soil by evapotranspiration.
>
> In the winter -- as rains increased, temperatures declined, and evapotranspiration rates slowed, stream flow swelled and the water table rose until it reached the surface. At this point streams overflowed into the swamp and surface sheetflow toward the east and south predominated.
>
> By spring the swamp was flooded to its maximum extent with little lateral water movement. As temperatures rose and plants began to grow in the late spring, evapotranspiration removed large quantities of water from the swamp and the water table began to drop below the ground surface. This allowed soils to aerate and vegetation to obtain oxygen needed

for growth. While there were fluctuations in the annual cycle of surface water within the swamp, subsurface water losses were moderated by the large water holding capacity of the peat soils."

Water Dynamics:

Great Dismal Swamp NWR's water budget is influenced by several natural input-output events. Direct precipitation is a major source of water, contributing about 28.5 billion gallons to the refuge annually and accounting in part for the fact that more water flows out of the refuge than enters it as surface inflow. Precipitation is highest during the summer months.

Washington Ditch . *By late winter, streams have swelled and overflowed into the swamp. Sheetflow. USFWS.*

Surface water inflow occurs in the form of stream and sheet flow from the west along the Suffolk Scarp. About 82 square miles of upland area drain into the refuge, primarily via Cypress and Taylor Swamps, supplying approximately 22 billion gallons of surface water each year. Eighty-nine percent of this inflow occurs from November through April. Evapotranspiration in areas upstream from the swamp severely limits inflow during summer despite higher rainfall rates.

Evapotranspiration accounts for the biggest portion of water removal from the swamp ecosystem. It exceeds rainfall during the growing season and causes a lowering of water levels in the refuge throughout the summer. Estimated annual evaporation loss from the refuge is about 39 inches (data from Dismal Swamp Canal hydrology substation). The rate of transpiration is not known.

Surface water runoff through the swamp is also a major means of outflow. Historically, the principal drainages have been the Northwest, Pasquotank, and Elizabeth Rivers, and Shingle Creek. Much of the winter discharge within the swamp was in the form of sheet flow. During low flow periods, the water would follow the random channels cut during high flow. Over the last two centuries natural outflow patterns have been altered; most surface water now drains through the refuge in the network of canals and ditches with minimal sheet flow.

Ground water discharge is a secondary output event. Wherever the upper layer confining the shallow aquifer is absent, ground water wells up into the overlying peat and is discharged from the peat by evapotranspiration. Ground water is also discharged by seeping directly into Lake Drummond. Where the aquifer is breached, ground water is discharged from the refuge as surface flow through outlet channels that are left uncontrolled.

Current hydrologic setting:
The hydrology of the Great Dismal Swamp has been modified through years of human activities. The ramifications of these changes are not fully understood but a few generalizations can be made. The amount and rate of annual surface inflows into the refuge have increased due to upland land use practices such as field tiling, road building, and housing along the Suffolk Scarp. Water that used to recharge the shallow aquifers and enter the swamp as much delayed ground water, is now intercepted and diverted into the refuge as surface water. This increase in the volume of surface water contributes to higher surface water levels during winter and storm events and may be in part responsible for reduced volumes of water to recharge the swamp during dry summer periods.

Ditches

Within the refuge, the construction of 158 miles of canals and ditches with their attendant spoil bank roads have combined to form the single most significant alteration to the swamp's water regime. The elevated spoil bank roads serve as dams blocking overland water flow. Conversely, those ditches without controls can quickly shunt water through to the swamp. In those areas where the confining layer was removed from the underlying artesian aquifer, ground water can also be shunted through during periods of low water. The loss of the artesian waters may reduce an important buffer needed for spring and summer evapotranspiration drawdown.

Many of the refuge's ditches form a network that channels much of the current surface flow into Lake Drummond, which in turn drains into the Feeder Ditch through a gated spillway and then into the Dismal Swamp Canal. Other ditches, including Corapeake, Big Entry, and several smaller ditches, drain directly into the Dismal Swamp Canal. Several ditches in the southern portion of the swamp drain into Cross Canal and ultimately into the Pasquotank River basin. Jericho Ditch drains northwest to Shingle Creek and also south to Lake Drummond. Due to flat terrain, the flow in several ditches is reversible, depending on rainfall, obstructions, and other factors.

The Dismal Swamp Canal has had a powerful effect on the hydrology of the swamp. The canal intercepts a majority of the surface water flowing out of the swamp and has breached the artesian aquifer. Lake Drummond is the primary source of water to operate the canal. Water flow through the canal is managed by locks at either end of the canal and by the spillway on Feeder Ditch at Lake Drummond.

Of all available incoming water (precipitation, surface inflow, and ground water), Lake Drummond receives approximately 25 billion gallons; the lake has a capacity for 4.62 billion gallons. 3.5% of outflow from the lake is used for the operation of the two locks on the Dismal Swamp Canal. The remaining 96.5% of available water is discharged as it exceeds the holding capacity of the swamp.

The effects of the roads on ground water are not clearly understood, but it is assumed that associated soil disturbance, compaction, and addition of outside materials to swamp soils have significantly altered historical patterns of ground water movement through the swamp. Questions remain as to the permanence and irreversibility of these subsurface dams.

Prior to federal acquisition of the Great Dismal Swamp, the private owners recognized the need for water conservation and control to reduce water losses. Previous owners installed 115 water control devices and culverts over the years. Many of the structures deteriorated over time, but the Service has repaired or replaced most of the critical water control structures since the refuge's establishment. These control structures have reduced water losses in the swamp .

Surface water levels and the ground water table are highest from December through April and lowest from May through November.

Feeder Ditch . *Water from Lake Drummond spills into the Feeder Ditch and then into the Dismal Swamp Canal.*
Photo:Waverley Traylor.

Lake Drummond

Lake Drummond, located near the center of the refuge, is one of only two naturally occurring lakes in Virginia. This 3,108-acre lake is shallow and nearly circular in shape (2.7 miles north-to-south and 2.4 miles east-to-west). At its deepest point, Lake Drummond is only 6 to 7 feet deep. It is perhaps the most widely recognized feature of the Great Dismal Swamp NWR.

The water level in Lake Drummond is intensively managed. A 1977 informal agreement between the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers defines a minimum lake level of 15.75 feet above mean sea level to retain sufficient water in the swamp ecosystem. When the water level is below this, water cannot be released from the lake for Dismal Swamp Canal operations.

Surface water quality is generally good. The dark tannic color and 3.5-6.7 pH level impart a distinct taste and heighten the water's ability to remain fresh.

Water Quality

Fertilizers and pesticides used on corn, soybeans, cotton and peanuts, and runoff from hog operations are potential surface water pollution sources. In addition, sediment flowing into the refuge from upstream agricultural and timber lands may eventually affect the free flow of water through the swamp and diminish water quality.

Water from the Norfolk aquifer is commonly soft with a generally low mineral content, although some areas have excessive iron and free carbon dioxide that may cause corrosion problems. The shallow aquifer is potentially susceptible to contamination from agricultural, industrial, or domestic runoff.

Nansemond NWR Water Quality

According to the Virginia Department of Environmental Quality (DEQ), some water quality problems exist in the Nansemond River. A fish eating advisory for Kepone exists for the James River and all its tributaries from the fall line at Richmond to the Hampton Roads Bridge Tunnel. It became effective on July 1, 1988, but there are no restrictions on fish consumption.

For all tributaries and mainstems of the Nansemond River, the watershed is classified as "nutrient enriched" under Virginia Water Quality Standards. This is likely due to non-point source contributions from agricultural, urban/suburban and forestry activities. DEQ has given the Nansemond River an overall water quality ranking of medium. The U.S. Environmental Protection Agency regulations require the states to give a priority ranking to identify those waters scheduled for Total Maximum Daily Load (TMDL). A ranking of medium identifies those waters scheduled for TMDL development by the year 2006.

Air Quality

The U.S. Environment Protection Agency (EPA) promulgated national ambient air quality standards in 1997 for PM2.5 (particulate matter equal to or less than 2.5 microns in diameter), however monitoring devices were not fully installed and operational until January, 1999. PM2.5 is one of six "criteria" pollutants for which standards have been established by the EPA Office of Air Quality Planning and Standards. The EPA determined that these standards are necessary to protect human health and the environment (Virginia Department of

Environmental Quality website, February, 2003). Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings (www.epa.gov/airs/criteria.html). For PM2.5, the threshold for the annual arithmetic mean is 15 ug/m3 for primary and secondary standards, while the threshold for the 24-hour average is 65 ug/m3 for primary and secondary standards (See Figure 2-2).

VIRGINIA 2002

PM2.5 PARTICULATE MATTER SUMMARY BY REGION

METHOD CODE 118 - GRAVIMETRIC, R & P MODEL 2025 SEQUENTIAL

Micrograms Per Cubic Meter (ug/m3)

LOCATION	NO. OF OBSERVATIONS BY QUARTER				HIGHEST VALUE PER QUARTER				QUARTERLY ARITHMETIC MEAN			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
TIDEWATER REGION												
CHESAPEAKE Oscar Smith Stadium	79	89	82	82	23.3	25.3	49.4	30.1	10.4	12.1	13.7	11.2
HAMPTON Va. School for the Deaf & Blind	28	30	26	30	19.7	17.5	32.9	22.5	10.4	11.0	13.6	11.6
NEWPORT NEWS Pump Station #103	28	30	28	28	17.7	18.8	33.7	33.5	9.8	11.8	14.6	11.4
NORFOLK NOAA Facility	29	27	31	31	19.9	22.1	50.8	21.2	10.7	11.9	16.6	11.4
VIRGINIA BEACH Tidewater Regional Office	28	26	28	31	21.9	22.5	50.2	26.8	10.8	11.2	15.8	12.1

Figure 2-2. *Particulate matter is the primary pollutant released during wildfires and during prescribed fire operations. Prescribed fire is used at Great Dismal Swamp NWR to improve wildlife habitat, maintain fire-dependent plant communities, and to reduce hazardous fuel accumulations near buildings and development. The data presented above represents sampling stations that may detect significant PM2.5 emissions from prescribed fire activities on the Refuge (the Chesapeake location is closest). As this data demonstrates for 2002, the threshold value for PM2.5 was never exceeded for the 24-hour average or the annual average.VDEQ.*

Contaminants/Hazardous

Great Dismal Swamp NWR Environmental Concerns

Resources of the Great Dismal Swamp NWR may have been (or continue to be) exposed to environmental contaminants from a variety of sources. To investigate the level of contaminants, the U.S. Fish and Wildlife Service sampled for three groups of pollutants: heavy metals, organochlorine pesticides, and alkanes (a constituent of petroleum products). Samples were collected from sediments, surface waters, and from the tissues of fish and small mammals during 1987, 1989, and 1992 (Kane, 1997). None of the sites demonstrated high levels of contaminants, though several areas on the refuge demonstrated higher levels than other sites. The areas exhibiting elevated levels of contaminants include the East Ditch area, where potential sources of contamination are the heavily used US Highway 58 and an automobile junkyard; the Cypress Swamp area demonstrated elevated levels of metals, but a potential source was not identified; and Lake Drummond fish showed elevated levels of mercury, chromium, nickel, and iron. Kane (1997) noted that it is well-documented that wetlands and swamps may act as sinks for metal contaminants, particularly mercury. Mercury is known to bioaccumulate and it is significant that top predators in Lake Drummond demonstrated the highest mercury levels, despite the fact that mercury was not detected in Lake Drummond water samples.

It should be reiterated that no high levels of contaminants were detected, only elevated levels in select areas. Kane (1997) suggests that this data be used as a baseline and that periodic monitoring of sediments and biota be conducted.

Nansemond NWR Environmental Concerns

A site survey was performed on April 15, 1997, by the Virginia Field Office (VAFO), U.S. Fish and Wildlife Service, Division of Ecological Services. During the survey, staff from the VAFO and the Great Dismal Swamp NWR walked the entire perimeter and most of the inner area of the 208 acres transferred to the Service in 1999. The purpose of the survey was to ascertain the likelihood of the presence and/or extent of hazardous substances or other environmental problems associated with the property. As environmental investigations and remediation have been ongoing at this site under the Installation Restoration Program (IRP), the property has been divided into several sites. The following descriptions and restrictions

correspond to designations defined through Defense Base Closure and Realignment Commission (BRAC) activities.

The first area surveyed comprises all of BRAC Sites 5 and 11 and most of the areas adjacent to these sites. Site 5 is the polychlorinated biphenyls (PCB) spill area near Star Creek. Soils in this area were contaminated by leaking transformers that were previously stored there, and historical reports indicate that oil in the transformers was drained into 55 gallon drums before being discarded into the marshy area. Results from soil sampling showed levels of PCB's up to 15,000 parts per million (ppm) in soil and 1 ppm in sediment, levels that are consistent with PCB clean-up goals at Superfund sites in the Environmental Protection Agency's Region 3. Clean fill was layered over site soils to minimize potential exposure of ecological receptors to remaining levels of PCB's in soils.

Restrictions for Site 1 prohibits the extraction of shallow groundwater and any disturbance of the surface and/or subsurface area without prior written approval of the Department of the Navy. Disturbance shall mean any intrusive activity that involves the penetration of the surface soil; such as excavation, trenching, tilling of the soil, and/or any mechanical or manual drilling. These prohibitions are intended to control the risk of direct contact with or consumption of water from the shallow aquifer and to control the risk of direct contact with or consumption of subsurface soils in contact with the groundwater in the shallow aquifer where contamination (124-trichlorobenzine) has been found to exceed the maximum contaminant level for drinking water.

The Site 7 restrictions prohibit disturbance of any surface or subsurface soils as above. The contaminant present in this case is low levels of Polynuclear Aromatic Hydrocarbons (PAH's).

Site 11 is adjacent to Site 5 and is designated as "The Disposal Pits." Construction debris was found at this site during PCB remediation activities at Site 5. The debris included shingles, wood and metal fascia.

During the April 15, 1997, site visit, a large dirt pile with a grass cover was observed. It is likely that this dirt pile is leftover clean fill that was brought in for remedial activities at Site 5. Other debris observed in the vicinity included a telephone pole, a wooden pole, a metal structure with wire conduits on the backside, and a metal container in Star Creek.

Aesthetics

The assessment of the Great Dismal Swamp NWR's aesthetic quality assumes that: (1) Unaltered natural areas possess greater natural scenic potential than modified areas, although some scenic value can be ascribed to the altered landscape if it is in character with the wildlife mission of the refuge; (2) scenic areas that are separated or buffered from intensive development, eyesores, or other unattractive environments are more valuable than those that are not; and (3) while visual resources are important, the policy of habitat protection on the refuge precludes the most visually obtrusive activities.

Visual resources were qualitatively assessed for each of six general zones in the refuge, as follows:

Aerial Views

Great Dismal Swamp NWR is dramatic from the air, as the vast expanse of forest offers a startling contrast to the surrounding mosaic of farms and urban areas. At the center of the refuge, Lake Drummond forms a prominent focal point. Bald cypress snags jut above the general forest canopy. The ecological continuity within the swamp is broken only by the road and ditch network, and even this is seasonally obscured by the canopy. The scarcity of such landscapes on the east coast adds greatly to the refuge's value as an aesthetic resource.

Lake Drummond . *The most significant visual feature in the refuge.* USFWS.

Lake Drummond

The lake is the most significant visual feature in the refuge. Its expanse of water has a shoreline punctuated by cypress snags. The lake possesses qualities of vividness, near/far contrast, and pictorial composition that are unmatched in the rest of the refuge. Colors and light change constantly, and overall wildlife viewing opportunities, especially of resting and wintering waterfowl, are better than elsewhere on the refuge.

Feeder Ditch/Dismal Swamp Canal

These waterways offer some visual interest for visitors entering the refuge by boat from the east. Overhanging branches and views of wildlife balance the visual deficit of artificial ditch banks. Development along these water routes is generally in keeping with their function.

Road/Ditch Corridors

The corridors lacing the swamp are long, narrow, and straight. In many cases, the value of the roads as viewsheds is lessened because care must be taken in negotiating around potholes, eroded edges, obstructions, etc. Views through the trees are possible when the leaves are gone; during the growing season a solid wall of vegetation forms along the roads, creating a tunnel effect. Seasonal color adds to the visual quality of the swamp forests. Wildlife viewing opportunities vary: open areas along the road and open water in the ditches offer the best chance for sighting wildlife. Because of off-road access constraints, refuge public use and resource management activities often coincide along these corridors, making visual management an important factor in retaining the aesthetic values of the refuge.

Wooded Interior

Inaccessible to viewing by most refuge visitors, the forests in the swamp interior add to the mystery of the swamp. They harbor wildlife activity and buffer activity and noise between different swamp areas.

Swamp Periphery

The edge of the swamp offers only a hint of the vast forested area lying beyond. Along most of its periphery, the swamp acts as a backdrop for various landscapes including highways, farms, and residences. Because of the sudden disruption of forest lands by development or clearing, the swamp's essential character as a potential ecological isolate, or "island", is emphasized.

Biological Resources

Refuge Habitats and Regional Context

Birds. *Two hundred and nine avian species have been reported in the Great Dismal Swamp NWR. Woodduck. Waverly Traylor.*

The Great Dismal Swamp NWR is a matrix of unique habitat types, many of which are rare. Within the refuge are found typical pocosins of the southeast (here they exist at the northern extent of their range), some of the largest remaining Atlantic white cedar woodlands to be found anywhere, and potential restorable habitat for the federally-endangered red-cockaded woodpecker.

Fauna

Birds

Two hundred and nine avian species have been reported in the Great Dismal Swamp NWR. Within this group, 92 species nest in the swamp, 49 of which are year-round residents; the remainder are migratory breeders. Most of the breeding birds of Great Dismal Swamp NWR can also be found in smaller wetlands outside the refuge, but not in such abundance and high density. One hundred and eleven migrant bird species use the refuge during fall and spring migrations. See Appendix C.

Insects

Refuge invertebrates include many individual species. Matta (1979) listed 182 species of aquatic and semi-aquatic insects, but little information was provided regarding terrestrial insects. Much of this data gap has been filled by recent surveys of butterflies and skippers (Roble et al., 1999) and damselflies and dragonflies (Roble and Cuyler, 1999). These recent reports include 52 butterflies, 41 skippers, 22 damselflies, and 43 dragonflies from within the current boundaries of the Great Dismal Swamp NWR. Six of these species are dependent upon switchcane as their only larval food plant.

Fish

Twenty-seven species of fish occur in Lake Drummond and the ditches. Seventy-five percent of the total fish population consists of the yellow bullhead. The abundance of yellow bullhead and low recruitment of black crappies, a species preferred by fishermen, may be attributed in part to yellow bullhead eating the eggs of the crappie.

Reptiles and Amphibians

Sixty-two species of herptiles (reptiles and amphibians) have been found at Great Dismal Swamp NWR, and six additional species may be present (Mitchell et al., 1999). These include 19 toad and frog, nine salamander, ten turtle, eight lizard and 22 snake species. Three poisonous snake species are present: the copperhead is the most abundant, while the canebrake rattlesnake and eastern cottonmouth are much less abundant than formerly thought.

Mammals

At least forty-seven species of mammals are found in the Great Dismal Swamp NWR. The first scientific collection of mammals inhabiting the Dismal Swamp was initiated by the U.S. Department of Agriculture in the late 1890's (Handley, 1999). Modern occurrences are described in Bulmer et al. (1999), Handley (1979), Paschal et al. (1979), Rose (1999b), Rose et al. (1999), and Webster (1999).

Mammals. *At least forty-seven species of mammals are found in the Great Dismal Swamp NWR. Red fox. Photo: Waverley Traylor.*

The most recent studies, occurring in the 1990's, have sought to fill the gaps within the mammal record, particularly small mammals and bats. At least eight studies of small mammals in the Dismal Swamp are reported during the 1980's and 1990's (Rose 1999b), and four studies of bats (Rose et al. , 1999). It should be noted that while study areas often included the Great Dismal Swamp NWR, many studies sampled the historical Great Dismal Swamp and were not limited to the refuge.

Recent studies have recorded 16 species of small mammals in the Great Dismal Swamp (Bulmer et al., 1999, Rose, 1999b). Findings include four species of shrew, six species of mice, one species of rat, two species of mole, two species of vole, and the southern bog lemming (*Synaptomys cooperi helaletes*).

Ten species of bats have been documented in the Great Dismal Swamp

NWR, with one additional species occurring just beyond the margin of the swamp (Rose et al., 1999). Beyond inventory data, little additional information is known about bats in the Great Dismal Swamp. The exception may be the red bat (*Lasiurus borealis*), which was the most numerous species presented in the summary by Rose et al. (1999). The habits of the red bat in the Great Dismal Swamp are better understood thanks to records of bat activity (Rose et al., 1999) and analysis of stomach contents (Whitaker et al. , 1997).

Larger mammalian residents of the swamp include nutria (*Myocastor coypus*), river otter (*Lutra canadensis*), beaver (*Castor canadensis*), ground hog (*Marmota monax*), raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), mink (*Mustela vison*), grey fox (*Urocyon cinereoargenteus*), red fox (*Vulpes fulva*), grey squirrel (*Sciurus carolinensis*), southern flying squirrel (*Glaucomys volans*), white-tailed deer (*Odocoileus virginianus*), black bear (*Ursus americanus*), and bobcat (*Felis rufus*).

The Great Dismal Swamp contains a significant coastal breeding population of black bears in eastern Virginia and extreme northeastern North Carolina. Hellgren (1988) and Tredick (2005) estimated the population to contain 250 - 350 bears. The refuge's mission of habitat restoration and managing public access into the swamp enables the refuge to sustain a healthy bear population. In addition, the refuge serves as a reservoir to supply bears to colonize privately-owned lands near the refuge.

Harvest data for the cities that contain the refuge has remained relatively unchanged, with an average harvest of 19 bears for the past 11 years. For the cities of Suffolk and Chesapeake, 1998 (33) and 2003 (26) were the two highest harvests and 2001(6) and 2004(11) showing the lowest harvest (VDGIF, 2004). Though harvest rates over the past 11 years do not indicate an increasing bear population, additional data, including nuisance bears, observational data, and age structure indices provide evidence of an increasing black bear population (VDGIF, 2002).

One goal identified in the Virginia Black Bear Management Plan is to stabilize the black bear population at current levels in the cities of Suffolk and Chesapeake. In looking at the two studies (Hellgren, 1988 and Tredick, 2005) that were completed over 15 years apart, both indicating a refuge population of 250 - 350 bears, and coupled with rates for high human population growth and development in southeastern Virginia, the Great Dismal Swamp NWR has begun to examine management alternatives to proactively address potential conflicts.

The refuge's carrying capacity for white-tailed deer increased during

the first half of the century when logging created additional deer habitat. Because there has been little timbering on the Great Dismal Swamp NWR since 1976, the openings that deer depend on for food are reforesting, reducing their value as deer habitat. However, these impacts have been mitigated by the development of experimental forest management plots, prescribed burning, wild fires, and road maintenance (clearing and mowing).

To maintain an appropriate relation between the deer herd and its swamp habitat, white-tailed deer are annually hunted on the refuge. The health of the deer population continues to be evaluated through off-refuge deer hunt check station data (weight, age class distribution, antler development, physical deformities). These data have indicated a gradual but steady improvement in deer health since refuge deer hunts began in 1979.

Flora

The refuge contains several plant communities comprising various associations made up from a total of 340 vascular plant species. Botanically, the swamp is the interface between northern and southeastern coastal plain swamp vegetation types. Current vegetation patterns in the refuge reflect past human activities and associated changes in the water regime. Timbering, ditching, road building, and fire suppression have influenced recent vegetation diversity. In many cases, a vegetation community includes both species typical of historical water regimes and species indicative of the recent hydrologic alteration. However, some areas within the swamp are typical historical communities whose existence predates the extensive development of the 1940's and 1950's (See Figure 2-3).

Classification of the natural communities in the Great Dismal Swamp NWR follows The Natural Communities of Virginia (Fleming et al., 2001). These classifications closely follow those used in the North Carolina classification (Schafale and Weakely, 1990). Natural communities present at the Great Dismal Swamp NWR include:

Mesic Mixed Hardwood Forests
Natural Lake Draw-Down Shores
Non-Riverine Pine-Hardwood Forests
Non-Riverine Swamp Forests
Pond Pine Woodlands and Pocosins
Peatland Atlantic White Cedar Forests

Mesic Mixed Hardwood Forests

Mesic (medium-moist site) hardwoods are stands of mixed deciduous tree species occurring at the higher elevations and better-drained mineral soils of the refuge. These forests are situated in the extreme northern end of the refuge near North Ditch and Jericho Ditch, on the Suffolk escarpment along the western boundary, and on a series of sand ridges (mesic "islands" in the midst of the swamp wetlands) near Weyerhaeuser Road.

Tree species in this community include sweetgum (*Liquidambar styraciflua*), yellow poplar (*Liriodendron tulipifera*), beech (*Fagus grandifolia*), willow oak (*Quercus phellos*), water oak (*Q. nigra*), laurel oak (*Q. laurifolia*), white oak (*Q. alba*), swamp chestnut oak (*Q. michauxii*), cherrybark oak *(Q. pagoda)*, southern red oak *(Q. falcata)* on drier sites, blackgum (*Nyssa sylvatica*), ash (*Fraxinus spp.*), elm (*Ulmus spp.*), and red maple *(Acer rubrum)*.

Evergreen species occasionally found in this type include American holly (*Ilex opaca*), southern magnolia (*Magnolia grandifolia*), sweetbay *(Magnolia virginiana)*, and loblolly pine *(Pinus taeda)*.

The highest concentrations of Virginia least trillium *(Trilium pusillum var. virginianus)* [globally rare] occur in areas of this forest type near Jericho Ditch and Jericho Lane.

The mesic mixed hardwood community occupies 600-900 acres, or less than 1% of the refuge. It is not known if these species historically occupied any greater area within the refuge, but it is known that most peripheral swamp lands with this habitat type have been converted for agricultural use.

Recently, approximately 50-acres of this forest type has been reestablished, and another 65-acres preserved as part of a wetland restoration effort on private lands along the Suffolk escarpment, immediately south of Jericho Lane.

Natural Lake Draw-Down Shores

The only representation of this community type in Virginia lies along the margins of Lake Drummond in the Great Dismal Swamp NWR.

Non-Riverine Pine-Hardwood Forests

These appear to be successional stands that have replaced the once widespread "canebrakes" because of fire suppression. This community type presents opportunities for restoration of canebrakes. Rare species associated with the Non-Riverine Pine-Hardwood Forests include Virginia least trillium and Swainson's warbler (*Limnothlypis swainsonii*). Additionally, Roble et al. (1999) identified six species of Lepidoptera that are dependent upon switchcane as their only larval food plant.

Non-Riverine Swamp Forests

This community type is globally uncommon to rare. For the purposes of this document the Non-Riverine Swamp Forests are divided into two cover types: cypress-gum and maple-gum.

Vegetation trends.
Cypress-gum is considered to be relatively stable community in the Dismal Swamp.
USFWS.

Cypress-gum forests are typical southern swamp communities adapted to surface inundation (hydric conditions) for at least part of the growing season. The association covers 12% of the refuge, occurring in western areas of the swamp where standing water is abundant. Principal species include cypress (*Taxodium distichum*), tupelo gum (*Nyssa aquatica*), and Swamp blackgum (*Nyssa biflora*). Both mineral and organic soils support the community, with the organic layers ranging in depth from a few inches to several feet.

Cypress-gum was formerly the most extensive association in the swamp. Cypress trees now occur in fairly low density, and tupelo gum is present only in scattered areas. Although cypress and tupelo gum are climax species for undisturbed wet sites, blackgum and red maple have replaced them over much of their range due to selective cutting of cypress, drainage, and fire.

Maple-gum forests cover sixty percent of the Great Dismal Swamp NWR and consist primarily of red maple and blackgum (often in association with redbay, sweetbay, sweetgum, and yellow poplar). The range of the maple-gum association has increased in the swamp over the past 30 to 40 years, and it is the only refuge habitat type that is continuing to expand.

Red maple is sensitive to wounding, fungus rot, insect attack, and fire injury (although fire-killed trees sprout vigorously and may flourish as second-growth stands). The species is also susceptible to animal damage. Red maple reproduction may be almost completely suppressed where deer populations are excessive.

Pond Pine Woodlands and Pocosins

These are globally rare community types. Most of the pine woodlands occurring within the Great Dismal Swamp NWR consist of pond pine (*Pinus serotina*). Pond pine occurs on soils of high organic matter content in the swamp interior. Historically, this community type was maintained by fire, limiting hardwood composition. Pond pine woodland still dominates many acres in the southern portion of the refuge, however fire suppression has allowed an increase in the hardwood component.

Pocosin vegetation is commonly found in the understory of pond pine woodlands. A pocosin is a specific successional stage of many coastal palustrine wetlands, dominated by broadleaved evergreen shrub vegetation less than 20 feet tall. Pocosins occur in areas of poorly developed internal drainage on organic soils.

Fleming et al. (2001) does not distinguish between pond pine and pocosin communities because they generally occur together in southeastern Virginia (the northern extent for both communities). North Carolina does distinguish these communities and further separates pocosin into low pocosin and high pocosin (Schafale and Weakely, 1990). This background information is provided because approximately 800 acres of broad-leaved evergreen pocosin is located south of Feeder Ditch and north of Corapeake Ditch. This pocosin habitat covers less than 1% of the refuge, but represents one of the few occurrences of this community type in Virginia.

The community boundaries are indistinct, grading into the pine type. Species commonly found in this type include bitter gallberry (*Ilex coriacea*) or inkberry (*Ilex glabra*), fetterbush (*Lyonia lucida*), downy leucothoe (*Leucothoe axillaris*), titi (*Cyrilla racemiflora*), myrtle (*Myrica cerifera*), redbay (*Persea borbonia*), and scattered pond pine. Much of this community is being overtopped by maple and pine.

Peatland Atlantic White Cedar Forests

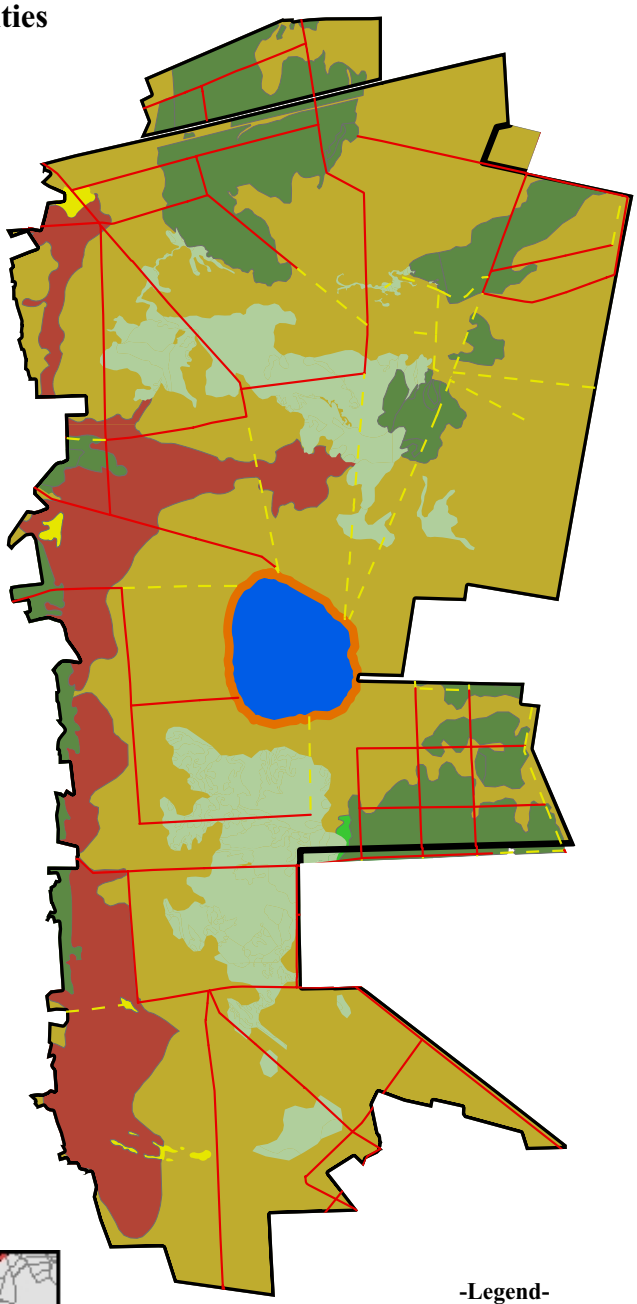
Atlantic white cedar forests are a globally rare community type. Atlantic white cedar (*Chamaecyparis thyoides*) occurs in both pure, even-aged stands and in stands mixed with swamp hardwoods such as red maple, blackgum, sweetbay, and redbay (*Persea borbonia*). Pond pine is also often associated with cedar.

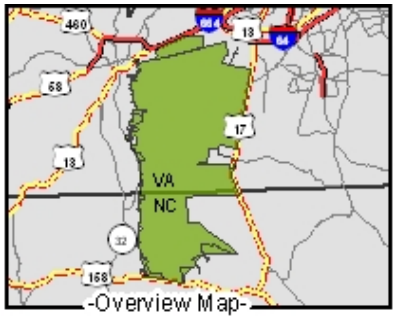
Atlantic white cedar stands are found on deep organic soils where

Figure 2-3.

Great Dismal Swamp
National Wildlife Refuge

Forest Cover Communities





-Legend-

- Maple-Gum Forests
- Mesic Mixed Hardwood Forests
- Non-Riverine Pine Hardwood Forests
- Cypress-Gum Forests
- Natural Lake Draw-Down Shores
- Peatland Atlantic White Cedar Forests
- Pond Pine Woodlands and Pocosins
- Maintained
- Unmaintained

0 1 2 4 6 8 Miles

the surface has become elevated above the water table. The species requires a 70-80% moisture level at the root mat, which is maintained by capillary movement of water from the water table through the fine-grained soils. However, the vitality of cedar is severely reduced if it is subjected to surface flooding during the growing season.

Atlantic white cedar is a subclimax but relatively long-lived type, developing after disturbances such as fire, flooding, windthrow, and clear cutting. In general, height growth virtually ceases and diameter growth slows greatly when Atlantic white cedar reaches 100 years old. Individual trees estimated to be nearly 1,000 years old have been recorded, but instances of cedar dominated forest communities reaching 200 years before breaking up and converting to a climax community are rare (Little and Garrett, 1990). Appropriate conditions for regeneration of pure stands of Atlantic white cedar are created either by crown fires in dense stands with little competing understory vegetation, or by surface fires that eliminate competing hardwoods and shrubs and that provide seedbeds above standing water. The lightning fires that burned large areas of the swamp in the past encouraged the regeneration of many more acres of Atlantic white cedar than currently exist.

Atlantic white cedar has been harvested in the swamp since the 18th century when the Dismal Swamp Land Company began operations. Loggers usually cut the Atlantic white cedar but left hardwoods to take over the site, or left so much slash on the ground that Atlantic white cedar seedlings were unable to develop in such shaded conditions. Other important factors in the gradual succession of Atlantic white cedar stands to hardwoods include suppression of wildfire and changes in the swamp's water regime.

In the Great Dismal Swamp NWR, Atlantic white cedar is present in pure stands covering approximately 3,600 acres, primarily in the south central portion of the swamp with a few stands north of Lake Drummond. Atlantic white cedar is also represented in approximately 8,200 acres of mixed cedar-hardwood community.

Unclassified Community Types

Four other wetland areas occur at the Great Dismal Swamp NWR that have a less clear fit following the Virginia natural community classification. Each likely represents Non-Riverine Swamp Forest altered by disturbance. These areas have previously been described as persistent emergent wetlands and occupy a total of less than ½ percent of the refuge. Despite this limited acreage, the emergent wetlands,

along with the pocosin areas, are the only non-forested vegetation communities on the refuge and thus contribute to habitat diversity.

North Ditch Bog (50 acres): An escaped fire, during low water table conditions, consumed several feet of peat from much of this unit. Most over story trees, mostly pine/maple, were killed. Beavers have now impounded this area and it remains flooded year round providing valuable waterfowl and bald eagle habitat.

Remnant Marsh (35 acres): Originally over 300 acres, this open marsh area has become overgrown by red maple. In 1986 the remaining 10 acres were burned to control woody encroachment. Twenty-five additional acres were cleared in 1994. The entire unit has been burned several times and is now maintained as a seasonally flooded open marsh.

Fringe Marsh (75 acres): The natural southward waterflow from the refuge is impounded by U.S. Highway 158 creating this narrow open marsh. A portion of the unit was cleared using heavy equipment in 1987. Additional acreage was converted from maple forest to marsh as the result of an escaped fire.

Railroad and West Marsh (5 acres): This area of maple/gum forest was cleared in 1985 using heavy equipment and has now been burned four times to maintain an open marsh habitat. Since 1996 beavers have impounded the area and are currently doing an excellent job of woody plant control.

Vegetation Development and Trends

Evidence indicates that the Dismal Swamp first began to develop along streams 11,000 to 12,000 years ago. A previous ice advance had left the area with characteristic boreal vegetation of jack pines and spruces. Over a period of 3,000 to 4,000 years the boreal vegetation was replaced by northern hardwood species that, in turn, was replaced by oaks, hickories, and other endemic southeastern species. The swamp gradually expanded westward along watercourses and peat began to accumulate. By 3,500 years ago, peat had blanketed the present-day Dismal Swamp, the water regime was saturated, and the oak-hickory forest was replaced by a cypress-gum swamp. Over time the composition of the swamp forest varied, as is evident today.

Future vegetation succession in the swamp cannot confidently be predicted. Many factors determine which species will gain dominance of a site, including intensity of fire, depth of peat burn, ground water

level, seed sources and methods of cutting, and the time of year. The continuing effects of human activities in the swamp now override natural influences on succession.

Rare Species. *Virginia least trillium. USFWS.*

In general the pioneer types -- Atlantic white cedar, pine, inkberry, cane, and red maple -- result either from fire or clearcutting. Red maple may also be a climax species. The cypress-gum, mesic hardwood, and mixed hardwood types are considered to be relatively stable communities in Dismal Swamp.

Rare Species

Federally-Listed Species

Red-cockaded woodpecker

The red-cockaded woodpecker (*Picoides borealis*) is a cooperative breeding species, meaning that the rearing of young usually involves the efforts of more than just the breeding pair. A 'group' is commonly composed of three or four individuals, but may include as many as nine. Helpers in the group are usually unmated males remaining from the previous breeding season.

The federally endangered red-cockaded woodpecker was observed on the refuge until 1974, though it was last observed nesting in the southeastern portion of the swamp in 1961.

Bald eagle

The bald eagle (*Haliaeetus leucocephalus)* is a federally-listed threatened species. Currently, there is one active bald eagle nest on the refuge. This nest was identified in 1997 and, though not active every year, has produced several young. In addition, over-wintering bald eagles are seen on the refuge almost every year. Guidelines for bald eagle protection have been developed jointly by the Virginia Department of Game and Inland Fisheries and the U.S. Fish and Wildlife Service, Virginia Field Office (VDGIF-USFWS, 2000). Because of the remote location of the bald eagle nest at the refuge, disturbance is highly unlikely. To insure minimal impacts, activities proposed within 1,320 feet (1/4 mile) of the nest will be reviewed by VDGIF and USFWS.

Red wolf

The Great Dismal Swamp NWR is located within the historic range by the federally endangered red wolf (*Canis rufus*), though no red wolves are currently known to inhabit the refuge. One red wolf was seen at the refuge in 1996. It was later trapped and returned to Alligator River NWR in North Carolina. If recovery efforts in North Carolina are successful, it is conceivable that red wolves could colonize the Great Dismal Swamp NWR.

State-Listed Species

Canebrake rattlesnake

The canebrake rattlesnake (*Croatalus horridus atricaudatus*) is a state-endangered species. The canebrake rattlesnake is found in two distinct populations in Virginia, the largest of which includes parts of Suffolk, Chesapeake, Isle of Wight, and Virginia Beach. The Great Dismal Swamp NWR is centered within this distribution.

Dismal Swamp southeastern shrew

Dismal Swamp southeastern shrew (*Sorex longirostris fisheri*) was removed from Endangered Species Act protection on February 28, 2000, however it retains its status as a Virginia state-threatened species. The shrew had held the status of 'threatened' since 1986.

Species of Concern

Four sensitive plant species are found in the Great Dismal Swamp NWR: Virginia least trillium (*Trillium pusillum var. virginianum*), which is a federal Species of Concern, and silky camellia (*Stewartia malacodendron*), sheep laurel (*Kalmia augustifolia*), and purple bladderwort (*utricularia purpurea*), on the Virginia Species of Concern and Watch lists.

The Virginia least trillium is restricted to the northwest corner of the refuge, although observations have been reported near the refuge boundary at the head of the Pasquotank River. The silky camellia is found in two locations: the mesic islands and in the northwest corner of the refuge. Great Dismal Swamp NWR is probably the northern limit of this plant's natural range.

Virginia Department of Conservation, Natural Heritage Program investigators sampling in the refuge during 1995 identified the following additional species warranting special concern from land managers:

Plecotis rafinesquii (eastern big-eared bat)
Megacephala carolina (tiger beetle)
Ilex coriacea (big gallberry)
Ludwigia pilosa (hairy seedbox)
Paspalum dissectum (water paspalum)
Solidago latissimifolia (coastal swamp goldenrod)
Tillandsia usneoides (spanish moss)
Xyris fimbriata (fringed yellow-eyed grass)

Noxious/Invasive Species

No comprehensive survey has been conducted to identify and locate invasive species at the Great Dismal Swamp NWR. The Virginia Natural Heritage Program and the Virginia Native Plant Society have prepared a list of invasive alien plant species of Virginia (http://www.dcr.state.va.us/dnh/invlist.pdf). While several may occur on the refuge, only phragmites (*Phragmites communis*) and shrubby bushclover (*Lespedeza bicolor*) have been documented.

Invasive animals on the refuge include coyote (*Canis latrans*) and nutria (*Myocastor coypus*). Coyote, native to the western U.S., have expanded their range to include the entire east coast of the U.S. Coyote have only been observed on two occasions at the Great Dismal Swamp NWR.

Nutria were intentionally introduced to the U.S. in 1899 for fur production. After initial introduction where they were pen-raised for their pelts, nutria were transported to various locations to control unwanted vegetation and enhance trapping opportunities. Ironically, the first nutria were brought to the Chesapeake Bay region in 1943 as part of an experimental fur station at Blackwater NWR on the eastern shore of Maryland. At Great Dismal Swamp NWR, nutria are only known to occur at three locations, in the Railroad and West Marsh, in Cross Canal Ditch, and in Corapeake Ditch.

The Role of Fire

Fire has influenced forest communities of the Great Dismal Swamp dating back to pre-colonial and possibly prehistoric times. Native Americans may have used fire as a vegetation management tool as well as a means of driving game during hunting. Most swamp fires result in the loss of highly combustible organic soils to depths of a few inches to six feet. Lake Drummond is believed to have formed from a large, deep burning peat fire.

Prior to 1900, fires within the Great Dismal Swamp were uncontrolled and usually occurred during droughts. Lightning ignited most of the fires, but Native American hunting parties and loggers may have ignited some fires.

From 1900 to about 1945, railroad and timbering activities brought new sources of ignition and increased the frequency of fires that burned for extended periods. Not only did timbering activity increase sources of ignition, those activities were concentrated during periods of increased flammability. Timbering in the swamp was most easily accomplished during dry periods when men and equipment could maneuver more easily on the peaty soils. This is also when the soils are more susceptible to ignition. Simpson (1990) reported on "The Great Conflagration", a logging slash fire that burned for years during 1923-1926, eventually burning an area of about 150 square miles (nearly 100,000 acres). Yellow peat smoke filled the air around Hampton, Newport News, and Norfolk during this period.

Since the mid-1940's, fire prevention and suppression techniques have reduced both the number and magnitude of fires within the refuge and adjacent areas. However, several notable fires during this period are summarized as follows:

•1955 Easter Sunday Fire: started along the railroad within the northern part of the current refuge and burned nearly 150 square miles, reaching the Portsmouth city line.

•1967 South of Feeder Ditch: Someone burning debris ignited this fire that burned 1,350 acres.

•1988 April Fools Fire: escaped prescribed fire burned 640 acres along the state boundary south of Lake Drummond.

1993 Clay Hill Road Fire: lightning caused fi re that burned 150 acres of pine stands near the refuge's western boundary in Suffolk.

1993 Portsmouth Ditch F ire: fire of unknown origin burned 75 acres adjacent the refuge in Chesapeake.

2004 Corapeake Road Fire: lightning caused fi re started on NC State Park land and spilled over onto the refuge burning 286 acres.

Today, lightning is the cause of most wildfires at Great Dismal Swamp NWR. A typical summer afternoon thunderstorm can often result in hundreds of lighting strikes on the refuge. Most of the time, the strikes do not create a wildfire, but surface and ground fires occur on average 2.6 times each year. Analysis of 30 years of fire history at the refuge has identified the wildfire season as March through October, with the peak fire season occurring from July 10 through August 18 (USDI, FWS, 1998).

Threats to human health and safety justify the extinguishment of wildfires, though many of the habitats at the refuge require periodic fire. Fires in the Great Dismal Swamp NWR can greatly affect air quality in surrounding urban centers (Chesapeake, Suffolk, Norfolk, Virginia Beach, and others). The products of fire result in decreased visibility and elevated levels of ozone and particulate matter, which creates poor driving conditions and elevates health risks especially for asthmatics, children and the elderly.

Most fires in the refuge interior cause only minimal damage because they are not threatening to refuge neighbors, are slow to spread, and do relatively little irreparable damage to resources (depending on extent, sensitive plant species, water quality, etc.) Burned areas within maple-gum forests regenerate, in most cases, to the same species or to early successional types.

Intense fires in Atlantic white cedar and pine forests, which generally contain more volatile fuel per acre, result in more damage. Surface fires in AWC are not as damaging, in fact, they are necessary for healthy stands. Ground fires are more threatening to AWC. Although the thick bark of pines offers protection from fire, Atlantic white cedar fairs more poorly. Ground fires often burn under the roots, causing trees to topple. Damage from deep ground fires prevents regeneration of dominant species, although moderately deep fires may provide conditions for wetland species regeneration. The Great Dismal Swamp NWR developed a Fire Management Plan in 1998. The Fire Management Plan identifies the following three priorities in descending order of importance: protection of human life and property losses, protection of fire sensitive refuge resources from wildlands fire

damage, and use of prescribed fire to perpetuate those communities needing periodic fires.

Current refuge fire management plans direct that all wildfires will be suppressed as quickly and as economically as safety permits. Wildfires usually occur when refuge water levels are low, creating conditions where long-burning ground fires could emit smoke into populated areas for extended periods. Moreover, the refuge is virtually surrounded by commercial and residential development, major highways, and airports. Therefore, containing the fire and smoke within an area that does not affect the human population adjacent to the refuge is difficult to assure. However, total suppression of wildfires contradicts the natural role of fire in the swamp ecosystem. In the past, periodic surface fires were important in perpetuating a number of early successional communities including Atlantic white cedar, loblolly and pond pine, and evergreen shrub. This critical role of fire as a natural process is increasingly accepted. The current Federal Wildlands Fire Policy states that "wildlands fire, as a critical natural process, must be reintroduced into the ecosystem" (USDA-USDI, 1996).

Prescribed fire, *At the Great Dismal Swamp NWR, prescribed fire is used to maintain unique fire-dependent habitats and restore habitats that have suffered from the absence of fire.* USFWS.

Prescribed Fire

Prescribed fire was first used successfully at the Great Dismal Swamp NWR in 1982 when 50 acres of loblolly pine on mineral soils were burned for hazard reduction and wildlife habitat improvement. Since then, the use of prescribed fire as a management tool has increased at the refuge. When properly applied, prescribed fire presents few of the health and safety threats associated with wildfire. Prescribed fire is applied under conditions that promote clean burning and the rapid ventilation of smoke and particulates from the lower atmosphere. Furthermore, prescribed fires are of limited size so that operations can be limited to only optimal burning conditions.

Natural resource professionals use prescribed fire for habitat restoration, fuels management, wildlife management, and vegetation management. At the Great Dismal Swamp NWR, prescribed fire is used to maintain unique fire-dependent habitats and restore habitats that have suffered from the absence of fire. These include Atlantic white cedar stands that require fire for regeneration and to prevent succession to maple-gum habitat, controlling invasion of woody plants in the remnant marsh, and creation of habitat for the federally endangered red-cockaded woodpecker. Fire may also be used as a management tool to limit expansion of maple and gum habitat type. These dominant species are not very fire tolerant and the extent of the habitat type in GDSNWR was historically limited by naturally occurring fire.

Prescribed fire is also used to reduce hazardous accumulations of fuels. The use of prescribed fire to reduce fuel accumulations at strategic locations minimizes the threat of wildfire to valuable resources. Fuels reduction fires are most commonly applied to land adjacent to development. This limits the fire intensity and minimizes damage if an accidental fire should occur.

Trial burns are being implemented under current management on organic soil types, emergent wetlands, and deep peat soils to test methods and effectiveness of burning as a habitat management tool.

Cultural Resources

Cultural History

Human occupation of the Great Dismal Swamp area dates back some 13,000 years, 4,000 years before the formation of the swamp began. Four cultural periods -- Paleo-Indian, Archaic, Woodland, and Historic -- represent a continuum of human inhabitation. The lifestyle of each period developed in response to local ecological conditions influenced by technological and sociological elements from other geographic and cultural areas.

By the time European colonists arrived, the area had acquired its swamp-like character and most Indians lived in peripheral settlements. The Nansemond Indians settled along the Suffolk Scarp; the present community of Chuckatuck is the site of one of their main towns. Artifacts of this tribe and others in the Powhatan Confederation as well as at least one independent group have been found throughout lowland Virginia and North Carolina. Their axes and other utensils indicate that they were a forest-oriented people.

Archaeological Resources

Archaeologists have unearthed ancient relics both within the refuge and along its edges. These discoveries have bolstered the theory that prehistoric people used the area as a hunting and fishing range abounding in waterfowl and other sources of food. Extensive prehistoric use of the Dismal Swamp area was possible because in

the remote past the area had a higher water level that prevented timber growth and allowed the existence of grasslands. The finding of corn pollen buried in peat not far from Lake Drummond by Donald Whitehead (1965) tends to confirm the notion that ancient people farmed in the swamp.

A cultural resources reconnaissance consisting of archival and background research and specific project impact assessment at Great Dismal Swamp NWR was undertaken during September and November of 1978 (Rappleye and Gardner, 1979). With the exception of noting that prehistoric sites are more likely to occur on well drained land within the confines of the swamp, no adequate predictive model can be developed on the basis of existing information.

Underground Railroad. *The refuge is a designated site on the National Parks Service's Underground Railroad Network to Freedom. "Osman." Harpers Magazine, September, 1856. By permission, Cornell University Library's Making of America Digital Collection.*

Underground Railroad Network to Freedom

The refuge is a designated site on the National Parks Service's Underground Railroad Network to Freedom. Primary source documentation indicates that the Great Dismal Swamp served as a hiding place for African-Americans escaping slavery in the 18th and 19th centuries. Historians believe these peoples established maroon communities in the swamp. As a part of the Underground Railroad, individuals used the swamp as a temporary hiding place until passage to the north could be secured. In 1847, the North Carolina State Assembly went so far as to pass the *Act to Provide for the Apprehension of Runaway Slaves in the Great Dismal Swamp and for other purposes*. In 1842, Henry Wadsworth Longfellow's poem "The Slave of the Dismal Swamp" and, in 1856, Harriet Beecher Stowe's novel *Dred*, highlighted the Swamp's reputation for hiding escaped slaves. At this time, limited archeological research has been completed to determine the location and existence of the maroon communities.

Socio-Economics

Population

Census estimates for 2002 place the population surrounding the Great Dismal Swamp NWR (Hampton Roads, Virginia, and adjacent North Carolina counties) at more than 1.5 million people. Furthermore, the region is continuing to develop rapidly. The cities of Chesapeake and Suffolk, where most of the refuge is located, have the highest growth rates in the region (See Figure 2-4). The City of Suffolk, once a rural tidewater county, is now one of the fastest growing areas in the U.S. Population for the City of Suffolk during the period July 2001-July 2002 grew at an astounding 4.8 percent,ranking it as the 33rd fastest growing city/county in the U.S. (U.S. Census, 2002).

The North Carolina section of the refuge falls within the counties of Gates, Camden, and Pasquotank. Total population in these counties was 52,298 in 2000.

	Population (7/02 Projected)	Population (2000)	Growth Rate (%) 1990-2000	Avg Income	% Below Poverty	Unemploy-ment
Virginia	7,293,542	7,078,515	14.4	40,209	11.6	
City of Chesapeake	206,665	199,184	31.1	45,427	10.1	4.2%
City of Suffolk	69,966	63,677	22.1	34,560	16.4	7.1%
North Carolina	8,320,146	8,049,313	21.4	35,320	12.6	
Camden County	7,465	6,885	16.6	35,423	12.2	6.7%
Gates County	10,635	10,516	13.0	30,087	15.4	5.5%
Pasquotank County	35,445	34,897	11.5	29,305	19.0	6.1%
Elizabeth City						
Surrounding Areas						
Franklin, City of	8,170	8,346	-0.5	31,687	19.8%	7.0%
Hampton, City of	145,921	146,437	9.5	36,297	14.6	5.9%
Isle of Wight County	31,085	29,728	18.7	39,331	11.6	5.3%
Newport News, City of	180,272	180,150	5.1	34,306	16.7	5.9%
Norfolk, City of	239,036	234,403	-10.3	28,350	24.4	6.1%
Portsmouth, City of	99,790	100,565	-3.2	29,815	20.5	7.3%
Virginia Beach	433,934	425,257	8.2	44,714	9.0	3.9%
York County	59,720	56,297	32.7	51,898	6.1	3.8%

Figure 2-4. *Population and Employment for GDSNWR region. US Census.*

Surrounding areas with the heaviest population concentrations (Chesapeake, Norfolk, Portsmouth, and Virginia Beach, Virginia) are located northeast of the refuge. Suffolk, Virginia is located northwest of the refuge, and Elizabeth City, North Carolina is south of the refuge. With these exceptions, the area immediately surrounding the swamp has a low density rural population. The refuge has no permanent residents.

Employment

The base economy within the refuge's service area is generally dominated by: (1) military bases and defense-related activities in the south-side Hampton Roads area and (2) extensive manufacturing, particularly shipbuilding activities, on the Peninsula. Historically, farming has been a large part of the local economy, and still continues to play an important role west and southeast of the refuge. Other important sectors are food processing, trade, retail sales, and services industries. The tourist industry is important in Virginia Beach, Virginia, and in the Outer Banks of North Carolina.

Agriculture and forestry are primary industries in the outlying rural areas. The major agricultural products are cotton, soybeans, corn, livestock, and poultry. The number of farms has declined, as is the case nationwide.

Public Use

While the primary goal of the Great Dismal Swamp NWR is to 'protect and preserve this unique and outstanding ecosystem,' a secondary goal is to educate the public about the ecosystem functions that the swamp performs. This goal is accomplished through a variety of public use activities:

Education

The Great Dismal Swamp NWR is a huge outdoor laboratory. It has been used since before the creation of the refuge to educate students of all ages. Bulmer (2000) states that vertebrate zoology students from Northern Virginia Community College have visited the Great Dismal Swamp annually since 1971. Researchers from Old Dominion University and Virginia Polytechnical Institute also frequently conduct studies in the refuge.

Area primary and secondary school systems are offered teacher activity/lesson guides and a refuge video for classroom use. Groups are invited to use refuge trails for the outdoor classroom activities. Staff and volunteers visit local schools and libraries to participate in additional educational programs.

Aside from formal educational programs, the Great Dismal Swamp NWR provides informative booklets and brochures to allow visitors to explore and learn at their own pace. The Great Dismal Swamp Coalition (the refuge's Friends group) also routinely schedules nature activities at the refuge.

Wildlife Dependant Recreation. *Trails for hiking/biking, wildlife observation and photography, and limited hunting opportunities are available at the Great Dismal Swamp NWR. Hiking visitors on Railroad Ditch Road. USFWS.*

Wildlife Dependent Recreation

The network of land ownership in the Great Dismal Swamp provides many wildlife and outdoor-related recreation opportunities. Trails for hiking/biking, wildlife observation and photography, and limited hunting opportunities are available at the Great Dismal Swamp NWR. Boating and fishing opportunities are present on Lake Drummond. Adjacent and nearby lands that provide similar opportunities include the Virginia Department of Game and Inland Fisheries (VDGIF) Great Dismal Swamp Wildlife Management Area (WMA), Virginia Natural Area Preserves, Nature Conservancy preserves, Northwest River Park, North Carolina State Natural Areas and State Parks. The Albemarle Region Canoe Trail System includes the Pasquotank River and Dismal Swamp Canal. Camping opportunities exist at Chesapeake's Northwest River Park and at the Lake Drummond Reservation (COE land).

Tourism

There is considerable potential for increased tourism to the Great Dismal Swamp NWR. Approximately 55 percent of the U.S. population resides within 500 miles of Virginia (Virginia Tourism Corporation, 2003a). The Hampton Roads area is already the most heavily visited part of the state. The Williamsburg area attractions accounted for three of the top five tourist attractions in Virginia in 1997-1998 and Williamsburg and Virginia Beach were in the top three cities visited in the state (Virginia Tourism Corporation, 2000). Total traveler spending in the Tidewater and Hampton Roads region of Virginia was nearly $2.5 billion in 2000 (Virginia Tourism Corporation, 2003a).

Within the Great Dismal Swamp ecosystem, numerous nature-based

recreational opportunities exist. These opportunities include wildlife observation, boating, camping, education, fishing, and hunting on lands of various ownership including natural area preserves, wildlife management areas, and parks, all of which rely heavily on the much larger Great Dismal Swamp NWR and Dismal Swamp State Natural Area (North Carolina) as the core resource areas. In addition, the North Carolina Dismal Swamp Canal Welcome Center is located three miles south of the North Carolina/Virginia state line, on the refuge's eastern boundary.

During the 2002 fiscal year, the Great Dismal Swamp NWR estimated 75,382 visitor-days (GDSNWR RMIS data). Interpretation and nature observation accounts for the vast majority of visits (96.3 percent), while environmental education (0.6 percent), recreation (3.4 percent), and off-site education and outreach (2.6 percent) accounted for the remainder of visitor activities [Since visitors may participate in multiple activities, the visitation by type exceeds 100 percent].

Political Setting

The Great Dismal Swamp NWR occupies portion of two cities in Virginia, Suffolk and Chesapeake, and three counties in North Carolina, Gates, Camden, and Pasquotank. In that, the refuge lies in the 4th Congressional District in Virginia, and the 1st and 3rd Congressional Districts of North Carolina. State representation finds the refuge in the 76th and 77th District for the Virginia House of Delegates, and the 14th and 18th Districts for the Virginia State Senate. In North Carolina, state representation finds the refuge in the 1st District for both the House and the State Senate.